IOSR Journal of Computer Engineering (IOSR-JCE)
e-ISSN: 2278-0661,p-ISSN: 2278-8727, Volume 21, Issue 2, Ser. III (Mar - Apr 2019), PP 53-58
www.iosrjournals.org

Improvement of Head Gesture Recognition using Camshift based Face Tracking with BLBP

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Abstract: *The task of face tracking is a key component of head gesture recognition system such as video surveillance and monitoring systems. The face tracking in different environmental conditions is a challenging research topic due to varying illuminations. In this paper, we present an improvement of head gesture recognition using camshift tracking algorithm with block local binary pattern. The camshift with block local binary pattern algorithm uses a background weighted histogram to distinguish the face from the background. As the shape and orientation of the face change, the window size is calculated to track the face. Finally, we use a novel feature extraction method called block rotation invariant uniform local binary pattern. The block rotation local binary pattern preserves the robustness to the illumination changes thus exploring the space structure to enhance the accuracy of the tracking. The experiments on the various video sequences illustrate the proposed algorithm performs the better compare to the traditional camshift tracking approach.*

Keywords: *Face Detection, Face Tracking, Head Gesture, Camshift and LBP.*

Date of Submission: 29-03-2019 Date of acceptance: 13-04-2019

I. Introduction

To improve the quality of the life for the elderly and disabled people, an electric powered wheelchair has been developed rapidly over the last twenty years (Simpson *et al*., 2004) (Cooper *et al*., 2005). Currently, most of the electric powered wheelchairs are controlled by the user's hands via joysticks and are very difficult for the elderly and disabled users who have restricted limb movements caused by the parkingson diseases and quadriplegics. The electric powered wheelchairs become more intelligent as cheap computers and sensors are embedded into the electric powered wheelchair and are named as intelligent wheelchairs. The various developments on intelligent wheelchairs have been carried out in the last decade such as Wheelesley (Yanco *et al*., 1995), CALL Smart Wheelchair (CALL Center, 1994), Nav Chair (Levine *et al*., 1999), Upenn Smart Wheelchair (Rao *et al*., 2002) *etc*.

The successful deployment of intelligent wheelchairs requires high performance and low cost. The main performance of intelligent wheelchair includes, the autonomous navigation capability for safety, flexibility, mobility, obstacle avoidance and the intelligent interface between users and intelligent wheelchairs including hand based control like joystick, keyboard, mouse, touch screen etc., voice based control like audio, vision based control like cameras, and other sensor based control like infrared sensors, sonar sensors, pressure sensors etc. As hands free interface, and head gestures have already been applied in some existing intelligent wheelchairs such as Osaka Wheelchair (Kuno *et al*., 2001), NLPR Wheelchair (Wei, 2004), EMG Wheelchair (Moon *et al*., 2005). However, these systems are not robust enough to be deployed in the real world and much improvement is necessary. The new generation of head gesture based control of wheelchairs should be able to deal with the uncertainties such as, background may be cluttered and dynamically changing, the user may have different facial appearances at different time, the face color may change dramatically in varying illumination conditions, and the user's head may move around for looking rather than moving.

K. Yuan *et al.* [1] presents the hands free control of an intelligent wheelchair which is based on the head gesture recognition of the user. The traditional face detection algorithm and object tracking algorithm are combined in the system to achieve accurate face detection, tracking and gesture recognition in the real time. This system is used as the human friendly interface for the elderly and disabled people to operate an intelligent wheelchair using their head gestures rather than their hands. The system uses camshift algorithm for the face tracking of the user. But the camshift has some limitation as it cannot accurately track the face when the illumination condition changes and it cannot work well under the cluttered background.

Yi Zhang *et al.* [2] proposed a novel head gesture recognition system in the application of the human wheelchair interaction. In this system, the adaboost algorithm is used to detect the lips of the user and the kalman filter predicts the lips. The kalman filter forecast the lips position detected by the adaboost algorithm may be appeared in the next frame first then detect the lips in the next frame. Compare the lip window position with a fixed point to confirm the head gesture correspondingly. The kalman filter overcome detects all the possible lips position by just use the adaboost algorithm in every frame.

Wen Hui Chen *et al.* [3] proposed an FPGA approach based Gesture Recognition System. In this system, the median filter is used for the skin color detection, optical flow for hand detection and the kalman filter for tracking. Using this system, the gesture detection and recognition can achieve 30 frames per second. The system software can subsequently schedule all tasks during processing. The system provides a simple background in an applied environment which can be used for consumer applications such as entertainment or medical applications, with non touch control equipment

Kawarazaki *et al.* [4] proposed a depth sensor based gesture recognition system. The system consists of an electric powered wheelchair with a depth sensor and a pc. The wheelchair moves according to the position of the hand. A depth sensor is used to recognize the hand gestures quickly. The system offers a hands freedom sense to the user, simplifying their daily activities by using the hands movements as the direction control input.

Klaus McDonald Maier *et al.* [5] proposed an intelligent wheelchair based on the head movements of the user in an indoor environment. In this system, there are the two operation modes which are based on the head movements. Mode 1 uses only one head movement to give the commands and Mode 2 employs four head movements. An Emotiv EPOC device is used to obtain the head movement information of the users.

Ralph Oyini Mbouna *et al.* [6] proposed a driver alertness monitoring system using eye state and head pose of the user. A support vector machine is used to classify a sequence of video segments into alert or non alert driving events. The system extracts visual features from the eyes and head movements of a driver in real outdoor driving condition

In this paper, an improvement of head gesture recognition using improved camshift based face tracking algorithm is used. In our approach, the head gesture recognition is conducted by means of real time face detection and tracking. For real time face detection, adaboost face detection algorithm and for face tracking, camshift object tracking algorithm is used. The block rotation invariant uniform local binary pattern is used for improving the poor performance of face tracking due to complex illumination, cluttered background and poses variations.

According to the above problems, the camshift algorithm combined with block rotation invariant uniform local binary pattern, a novel feature extraction method is proposed. In this method, the block rotation invariant uniform local binary pattern, a novel feature extraction method, explores the space structure to enhance the accuracy of the face tracking, in terms of preserving the robustness to the illumination and appearance variations.

II. Algorithm Principle

2.1 Adaboost Algorithm

Figure 1: Block Diagram of Adaboost Face Detection Algorithm

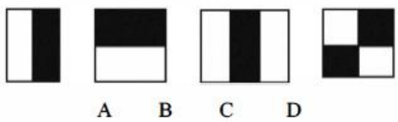

Figure 2: Haar like Character

Figure 1 shows the block diagram of adaboost face detection algorithm. Figure 2 shows the haar like features or characters.

The block diagram of adaboost face detection algorithm consists of a sequence of stages: an image capturing that is data acquisition; filtering that is pre processing; and feature extraction that is rectangular features. The Adaboost is the most recent face detection algorithm with both high accuracy and fast speed. It extracts the haar like features of images that contain image frequency information. A set of key features are selected from these extracted features. These set of features detect various faces under varying illumination conditions and different face colors. Adaboost also able to detect profile faces.

The haar like features are used for the face detection firstly then viola proposed the three kinds and four forms of the characters. The three types are: two rectangular characters, three rectangular characters and four rectangular characters. The haar like character is defined as the sum of the pixels which lie within the white rectangles subtracted from the sum of pixels in the gray rectangles.

2.2 Camshift Algorithm

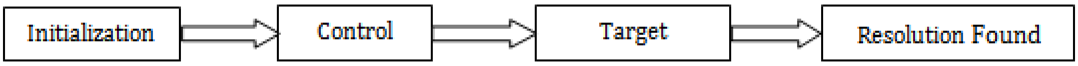

Figure 3: Block Diagram of Camshift Face Tracking Algorithm

Figure 3 shows the basic block diagram of the camshift face tracking algorithm.

The block diagram consists of four stages: 1. initialization; 2. control; 3. target search; and 4. resolution found. The camshift algorithm is basically used for the tracking of the user's face. It is the most powerful and mostly used for the tracking purpose. It correctly tracks the user's face. The camshift is based on the image hue. The hue is the true color attribute consisting of red, green, blue, orange, yellow, and so on. The tracking is one of the most difficult tasks because of the various environmental conditions and the changes in the facial expressions. The basic camshift has some limitations. These limitations are; in varying illumination conditions, the camshift gives poor results; it cannot work well under the cluttered background. The speed is fast but it fails in the various outdoor environmental conditions. The system needs to improve the tracking performance by improving the basic camshift. The camshift based unscented kalman filter is proposed to overcome the limitations by the basic camshift.

Camshift is a very efficient color tracking method based on image hue (Bradski, 1998). It uses a robust non-parametric technique for claiming density gradients to find the mode (peak) of probability distribution called the mean shift algorithm. Each iteration, Camshift aims to find the mean window center using a fixed window size. If either the window center or the window size is unstable, both values need to be adjusted accordingly until convergence.

III. Feature Extraction Method

3.1 Local Binary Pattern

The Local Binary Patterns (LBP) is a non parametric descriptor whose aim is to efficiently summarize the local structures of images. The LBP has most important property of tolerance regarding monotonic illumination changes and its computational simplicity. The Local Binary Patterns or the LBP Codes is defined as the operator which labels the pixels of an image with the decimal numbers, which encode the local structure around each pixel. In Local Binary Pattern, an image operator based on gray level differentiates between the centre and neighborhood of a pixel. The LBP is used in texture classification, pattern recognition and facial image analysis.

Example:

1	2	2
9	5	6
5	3	1

-4	-3	-3
4		1
0	-2	-4

0	0	0
1		1
1	0	0

Binary: 00010011; Decimal: 19

In the above example, the labels for the image pixels are obtained by thresholding 3 by 3 neighborhood of each pixel. Each bit is made 0 or 1 based on the difference in the intensities between the corresponding pixel and the central pixel. The string of bits obtained is followed in the clockwise or counter clockwise direction to get an 8 digit binary number. The binary number is converted into its decimal equivalent to obtain LBP label for the centre pixel. Since the 3 by 3 neighborhood consists of 8 pixels excluding the centre. The total of $2^8 = 256$ different labels is possible.

3.2 Block Rotation Invariant Uniform Local Binary Pattern

Thresholding 3 by 3 neighborhood of each pixel with centre value and considering the result as a binary. Then transform the region by the original LBP. The BLBP divides it into the four equal areas with the vertical and horizontal lines. The statistics shows the histogram for the each block. Then it combines with the color features to represent appearance model of face in tracking. The BLBP has an advantage of exploring space structure to enhance the accuracy of the tracking. It preserves the robustness to the illumination and appearance variations.

In BLBP, an image operator based on the gray level differentiates between the centre and neighborhood of a pixel taking average of pixels. It extracts the intensity differences between the centre pixel and surrounding average intensity values of the pixels in the blocks. Thus, can be shared more intensity values of the pixels in the blocks that contain different information that is not captured by the original LBP features.

In addition to LBP, to further increase the discriminatory power of LBP texture features, another new variant of the LBP, namely the block based LBP (BLBP) features. The BLBP compares the average intensity value of pixels in blocks of a certain shape in a neighborhood around the centre pixel. The two different shapes of pixel blocks namely spoke and ring are used.

The spoke based BLBP compares the intensity of the centre pixel with the average intensities of the neighbor pixels.

The ring shaped BLBP compares the intensity of the centre pixel with the average intensities of the neighbors in ring shaped areas around the centre pixel.

The overall BLBP feature vector is the concatenation of the SBLBP and RBLBP feature vectors.

BLBP = {SBLBP, RBLBP}

Example

Consider the 3 by 3 matrix:

1	2	2
9	5	6
5	3	1

Using SBLBP:

1	2	2
9	**5**	6
5	3	1

3.5	5	6
10	**5**	10
6	5	3.5

-1.5	0	1
5		5
1	0	-1.5

0	1	1
1		1
1	1	0

Binary: 01110111

Using RBLBP:

1	2	2
9	**5**	6
5	3	1

3.6	3.6	3.6
3.6	**5**	3.6
3.6	3.6	3.6

-1.4	-1.4	-1.4
-1.4		-1.4
-1.4	-1.4	-1.4

0	0	0
0		0
0	0	0

Binary: 00000000

IV. Comparative Analysis of the System

Table 1: Speed of Camshift

Environmental Parameters	Different Head Gestures	Minimum Face Size	Time Cost Per Frame
Sunshine	Frontal	123 * 123	0.0370 s
	Left	123 * 123	0.0026 s
	Right	123 * 123	0.0026 s
	Up	123 * 123	0.0030 s
	Down	123 * 123	0.0043 s
Cluttered	Frontal	100 * 100	0.0333 s
	Left	100 * 100	0.0047 s
	Right	100 * 100	0.0039 s
	Up	100 * 100	0.0026 s
	Down	100 * 100	0.0043 s
Shadow	Frontal	143 * 143	0.0406 s
	Left	143 * 143	0.0003 s
	Right	143 * 143	0.0040 s
	Up	143 * 143	0.0007 s
	Down	143 * 143	0.0032 s

Table 2: Speed of Camshift with Adaboost

Environmental Parameters	Different Head Gestures	Minimum Face Size	Time Cost Per Frame
Sunshine	Frontal	123 * 123	0.0350 s
	Left	123 * 123	0.0019 s
	Right	123 * 123	0.0025 s
	Up	123 * 123	0.0022 s
	Down	123 * 123	0.0041 s
Cluttered	Frontal	100 * 100	0.0339 s
	Left	100 * 100	0.0041 s

	Right	100 * 100	0.0027 s
	Up	100 * 100	0.0003 s
	Down	100 * 100	0.0008 s
Shadow	Frontal	143 * 143	0.0361 s
	Left	143 * 143	0.0040 s
	Right	143 * 143	0.0028 s
	Up	143 * 143	0.0022 s
	Down	143 * 143	0.0041 s

Table 3: Speed of Camshift with Unscented Kalman Filter

Environmental Parameters	**Different Head Gestures**	**Minimum Face Size**	**Time Cost Per Frame**
Sunshine	Frontal	123 * 123	0.0345 s
	Left	123 * 123	0.0026 s
	Right	123 * 123	0.0046 s
	Up	123 * 123	0.0008 s
	Down	123 * 123	0.0043 s
Cluttered	Frontal	100 * 100	0.0368 s
	Left	100 * 100	0.0022 s
	Right	100 * 100	0.0041 s
	Up	100 * 100	0.0026 s
	Down	100 * 100	0.0043 s
Shadow	Frontal	143 * 143	0.0406 s
	Left	143 * 143	0.0020 s
	Right	143 * 143	0.0008 s
	Up	143 * 143	0.0008 s
	Down	143 * 143	0.0046 s

Table 4: Speed of Camshift with Block Rotation Invariant Uniform LBP

Environmental Parameters	**Different Head Gestures**	**Minimum Face Size**	**Time Cost Per Frame**
Sunshine	Frontal	123 * 123	0.0012 s
	Left	123 * 123	0.0013 s
	Right	123 * 123	0.0014 s
	Up	123 * 123	0.0012 s
	Down	123 * 123	0.0020 s
Cluttered	Frontal	100 * 100	0.0011 s
	Left	100 * 100	0.0016 s
	Right	100 * 100	0.0015 s
	Up	100 * 100	0.0548 s
	Down	100 * 100	0.0418 s
Shadow	Frontal	143 * 143	0.0014 s
	Left	143 * 143	0.0014 s
	Right	143 * 143	0.0015 s
	Up	143 * 143	0.0013 s
	Down	143 * 143	0.0014 s

Table 5: Percentage accuracy in different methods

Sr. No.	**Tracking Methods**	**Percentage Accuracy**
1.	Camshift	48.57 %
2.	Camshift with Adaboost	57.14 %
3.	Camshift with UKF	63.33 %
4.	Camshift with BLBP	86.00 %

V. Conclusion

The head gesture based interface consists of real time face detection, tracking and gesture recognition. The Adaboost extracts the haar like features of the image which contain the image frequency information only by the integer calculation that is fast. The camshift algorithm is used for color tracking concluded to be fast object tracking method based on image hue.

The simulation result shows that the percentage accuracy of camshift face tracking is 48.57 %, Camshift with Adaboost Face Tracking is 57.14 %, Camshift with Unscented Kalman Filter is 63.33 %, and Camshift with Block rotation invariant uniform Local Binary Pattern is 86.00 %. So, the block rotation invariant uniform Local Binary Pattern feature extraction method improves the poor performance due to complex illumination, cluttered background and poses variations.

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IOSR Journal of Computer Engineering (IOSR-JCE) is UGC approved Journal with Sl. No. 5019, Journal no. 49102.

Rushikesh Bankar. " Improvement of Head Gesture Recognition using Camshift based Face Tracking with Block Rotation Invariant Uniform LBP " IOSR Journal of Computer Engineering (IOSR-JCE) 21.2 (2019): 53-58.